Information Systems Technology Technology Area Review and Assessment

Modeling and Simulation Technology

1 April 2004

Deputy Director, Technology
Defense Modeling and Simulation Office

TARA is the current method for implementing Project Reliance – the coordination process for 6.2 and 6.3 S&T across OSD and the Services. M&S falles under the Information Systems Technology.

TARA is run out of the office of the Deputy Secretary of Defense for S&T

M&ST Game Plan

7:30 Coffee
8:00 Intro Brief: Chair

8:35 IS.61 Human Behavior Representations: AFRL

9:10 IS.78 Modeling Architecture for Technology, Research and Experimentation: Director M&S Division, RDECOM SOSI

9:40 BREAK

9:50 IS.81 Composable Modeling and Simulation Framework: DMSO

10:15 IS.72, Integrated Live, Virtual, and Constructive Joint Urban Operations Training, SAIC, System Integrator

10:40 M&S Summary: Chair
5 minutes for transition to poster room
11:00 Posters

12:00 Panel Caucus / Lunch

MS&T Subgroup Members

Defense Modeling and Simulation Office
Alexandria, VA

Air Force Research Laboratory
Dayton, OH

Office of Naval Research
Arlington, VA

RDECOM
Ft. Monmouth, NJ

Primary M&ST DoD Players

- **Army Research Development and Engineering Command**
  - Distributed Labs: Aviation & Missiles (AMRDEC-AL),
  - Ground Platforms (TARDEC-MI),
  - Basic Research (ARL-MD),
  - Authoritative Analysis Data (AMSAA-MD),
  - C4ISR (CERDEC-NJ),
  - Munitions (ARDEC-NJ),
  - Chem/Bio (ECBC- MD),
  - Soldier Systems (NATICK-MA),
  - Training Visualization (STTC-FL)
- **Air Force Research Laboratory**
  - Information Directorate (Rome Research Site, NY)
  - Information Directorate (Wright-Patterson AFB, OH)
  - Sensors Directorate (Wright-Patterson AFB, OH)
  - Human Effectiveness Directorate (Wright-Patterson AFB, OH)
  - Space Vehicles Directorate (Kirtland AFB, NM)
- **Navy**
  - NSWC (Dahlgren, VA)
  - Naval Research Laboratory (Washington, DC)
  - SPAWAR Systems Center (San Deigo, California)
  - NAVAIR Orlando
  - SWOS: Surface Warfare Officers School
- **Defense Modeling and Simulation Office**
  - Service laboratories
  - Joint Components

Primary Applications

Utilize global research activities
- *Integrate, mature, and demonstrate emerging technology*
- *Develop and transition the right technology in the shortest time to our soldiers*

Model Abstraction, Multi-resolution modeling, Composable simulations, collaborative simulation, architecture modeling, synthetic environments, advanced engineering environments, modeling frameworks

Deployable Training
T&E
Mission Rehearsal
Blended Training Solutions (LVC)

Policy, standards, composability, validation, representation design

Technical Transition Targets

- **DoD**
  - **JFCOM (JUO, J9/JE, J7, JNTC, J8, J6)**
    - **(Under Transformation Guidance has significant responsibility for tracking simulation capability)**
  - **Joint Capabilities: OSD (JWARS)**
  - **Service training programs**
    - **Navy: BFTT (Battle Force Tactical Trainer)**
    - **AF: DMO, DMT (Distributed Mission Operations / Training)**
    - **Army: STTC/ PEO STRI**
  - **Service and Joint T&E (Joint Distributed Engineering Plant, Test Ranges, …)**
  - **Service Experimentation programs**
    - **Navy: FBE, NASMP (Fleet Battle Experiments, Navy Air Simulation Master Plan)**
    - **AF: AFEO (Air Force Experimentation Office)**
    - **Army: TRADOC (Training & Doctrine) – TRAC (TRADOC Analysis Center) and Battlelabs**
  - **Direct transition into operations**
    - **Navy: Fleet Combat Training**
    - **AF: ACC, AMC (combat, mobility)**
    - **Army: AAIC (Army Architecture Integration Cell), OEF/OIF (Operations Enduring/Iraqi Freedom)**
  - **Institutionalization in Service operational functions**
    - **Army: Use of M&S technology to evolve investment strategy**
- **Commercialization of Capabilities (Domestic and Foreign: Runtime Infrastructure)**
- **Other Government Agencies**
  - **New York City: Police Department, Metropolitan Transit Authority**
  - **Department of Homeland Security**
  - **Department of Commerce: NIST (National Institute for Standards and Technology)**

Comparison of Commercial and Military Modeling & Simulation Efforts

COMMERCIAL MILITARY

Commercial

- Gaming
  - Fantasy worlds (entertainment)
  - Stories and Characters
  - 60%-80% believable, functional - okay
- Visual Environment
  - Prioritizing/rendering of graphics
  - Artists involved with visuals
  - Human immersion an art
- Network Environment
  - Few distributed sims (on Internet)
    - Not as time sensitive
- Interoperability
  - Market driven
  - Linkages to proprietary hardware
  - Custom linkages of proprietary tools and systems

Fantasy

Physics-Based

Characters

HBR

Proprietary Links

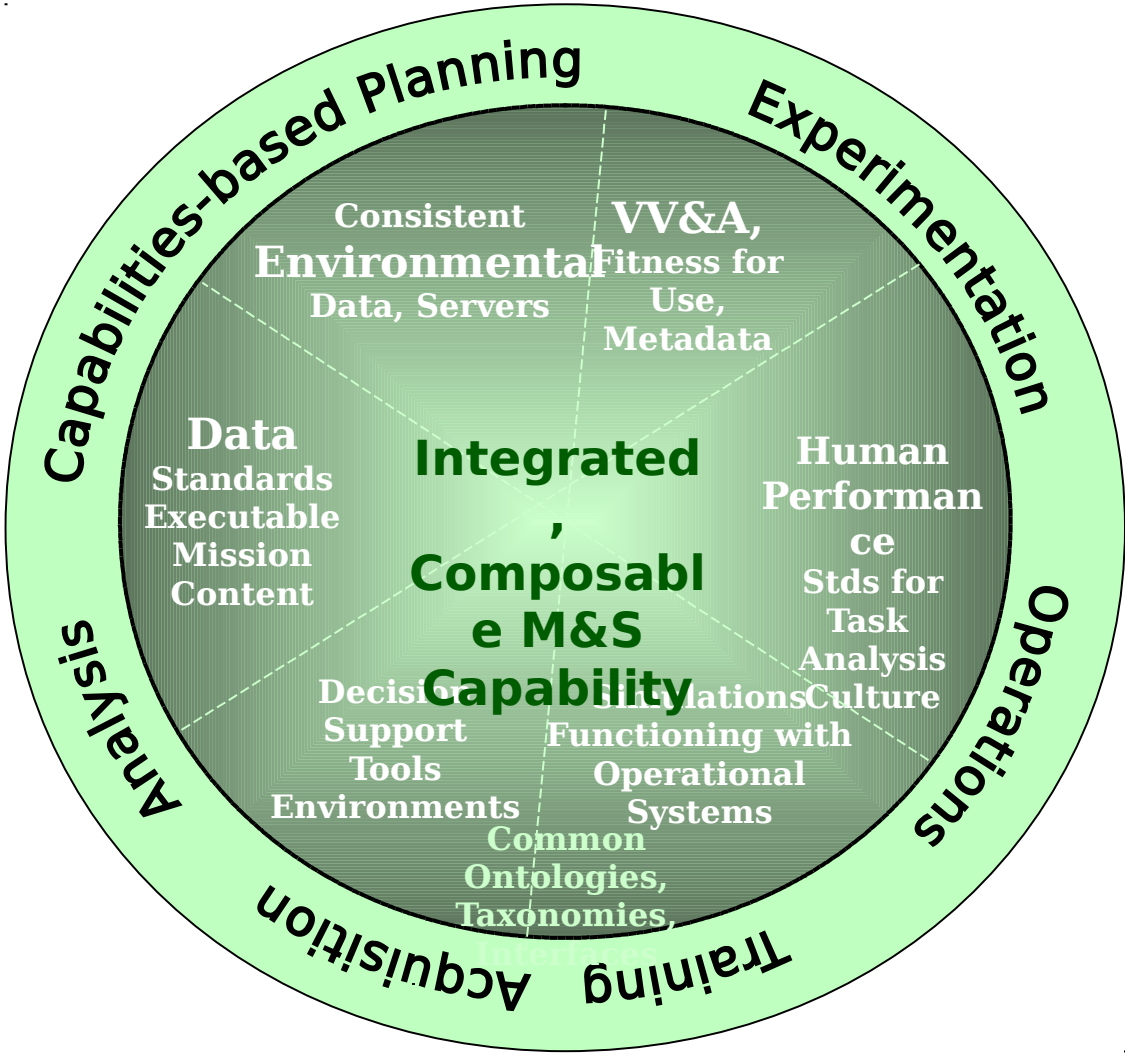
HLA/RTI

Military

- Wargames
  - Representation of physics- & behavior-based reality
  - Human/org behavior representation
  - Near 100% ready and VV&A'd
  - Accreditation by user
- Visual Environment
  - Engineers develop visuals
  - Real-time graphics generation
  - Human immersion progressing
- Network Environment
  - Distributed and collaborative
    - Real-time, low latency
  - Linkages to live C4ISR systems
- Interoperability
  - Open system linkages of many disparate databases, models, & sims
- Reduce development/set-up costs

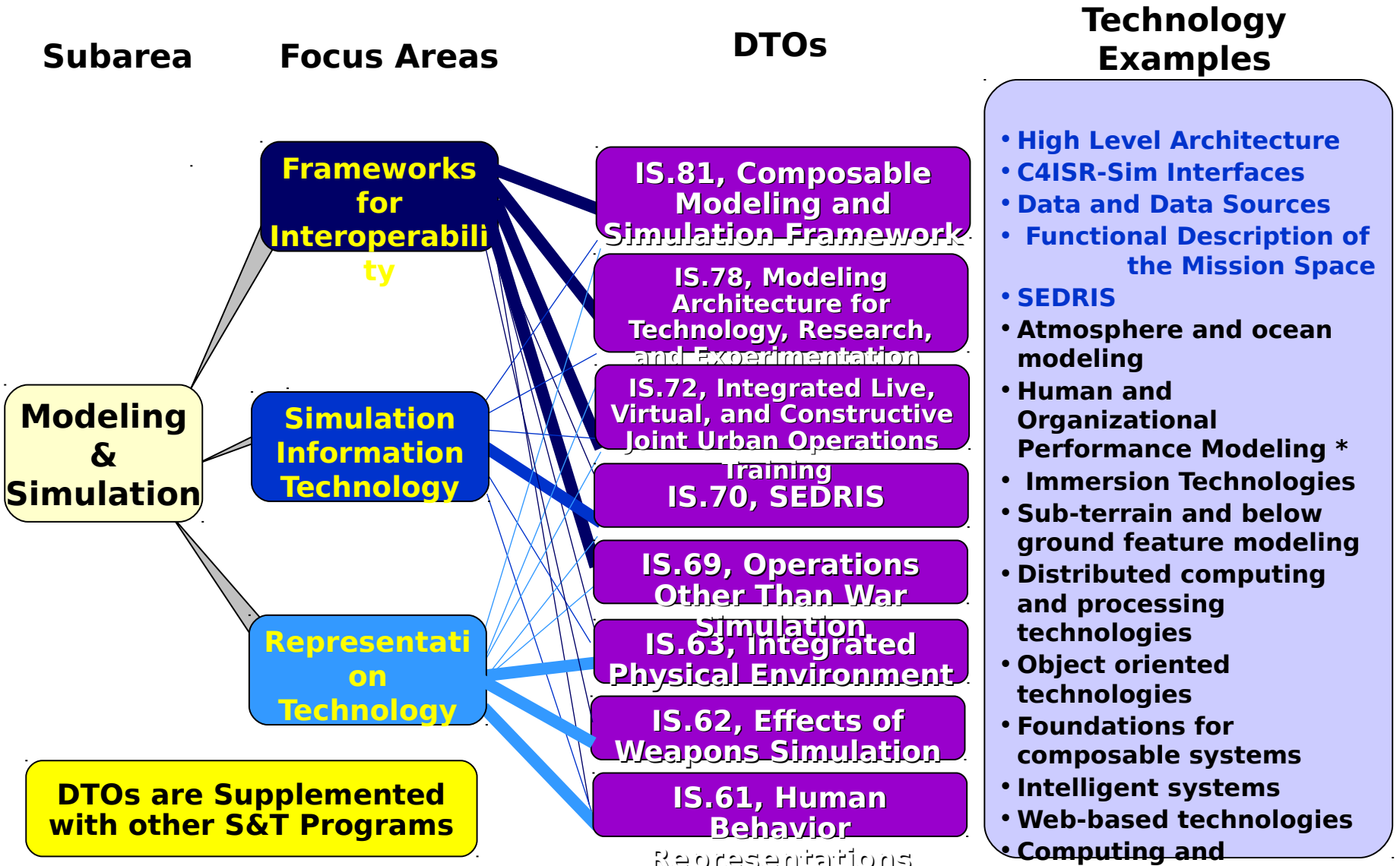
Building Capability = Focusing Diverse Technologies on a Target

- Grand Challenge Problems in M&S
- The six sectors focus on *maturing essential technologies* that are beyond the capability of any individual program to address and have been named nationally and internationally as Grand Challenges for M&S.
- Underlying these Grand Challenges and critical to providing an integrated capability in M&S are information technologies that are the focus of this panel
  - Frameworks for composability
  - Simulation Information Technologies
  - Representation Technologies
- *A composable M&S framework* is needed if we expect to develop a nimble, responsive, integrated, M&S capability over the full range of DoD applications



M&ST DTO Structure

Cross-talk between R&D and S&T Applications is Evident in Technology Examples


Subarea
Focus Areas
DTOs
Technology Examples
Modeling & Simulation
Frameworks for Interoperability
Simulation Information Technology
Representation Technology
IS.81, Composable Modeling and Simulation Framework
IS.78, Modeling Architecture for Technology, Research, and Experimentation
IS.72, Integrated Live, Virtual, and Constructive Joint Urban Operations Training
IS.70, SEDRIS
IS.69, Operations Other Than War Simulation
IS.63, Integrated Physical Environment
IS.62, Effects of Weapons Simulation
IS.61, Human Behavior
Representations
• High Level Architecture
• C4ISR-Sim Interfaces
• Data and Data Sources
• Functional Description of the Mission Space
• SEDRIS
• Atmosphere and ocean modeling
• Human and Organizational Performance Modeling *
• Immersion Technologies
• Sub-terrain and below ground feature modeling
• Distributed computing and processing technologies
• Object oriented technologies
• Foundations for composable systems
• Intelligent systems
• Web-based technologies
• Computing and
DTOs are Supplemented with other S&T Programs

Focus Area: Representation Technology

Develop design standards and tools to enable construction of authoritative representations of synthetic natural environments and systems

IS.63, Integrated Physical Environment
IS.62, Effects of Weapons Simulation—Link to JWSTP
IS.61, Human Behavior Representations

Near Term Goals	Mid Term Goals	Far Term Goals
Demonstrate agent-based technology that can insert social, political, and economic cascading secondary effects into a joint exercise.	Demonstrate advanced behavioral models of organizations and operational teams.	Provide variable behavior (reactions under stress, cultural responses, crowd, and others).
Demonstrate and validate that automated predictive modeling tools can support the user's ability to independently develop predictive models of current asymmetric adversaries and emulate their likely responses to specific U.S. and Allied actions.	Address interchange of dynamic human and organizational behavior environmental attributes and related effects. Establish integrated production capability to meet operational and M&S user needs.	Integrate both static and dynamic physical environments. Integrated databases derived from terrain, ocean, atmosphere, and space source data support the representation of large numbers of environmental conditions and effects in a consistent and correlated manner in both stand-alone simulations and federations of heterogeneous simulation applications.
Investigate very high-resolution database designs and access to 3-D environmental model libraries. Demonstrate production and use of operational resources with scenario generation system modular components and transition the library services central access site.	Develop expanded capabilities to provide multiple environmental scenarios allowing simulation users to have alternate environmental conditions depending on training objectives.	Capability to model, visualize and analyze multiple, simultaneous yet dissimilar, WMD scenarios.
	Inject Integrated WMD Toolset	Complete integration of simulation capability into Weapons of Mass Effects Battle Lab to support ops research for

IS.62 Effects of Weapons Simulation Links to the JWSTP

- **Develop physically accurate, real-time simulation of weapons effects for training, mission planning and rehearsal, test and evaluation**
  - High-Level Architecture (HLA)-compliant simulations for weapons effects, nuclear, biological, and chemical (NBC) environments, NBC defense, and C2 operations
  - High-fidelity, physics-based models and databases of targets, weapons, and after-strike effects that support the real-time/near-real-time viewing of the effects of weapons in a simulated environment
- **Challenge**
  - automated generation of target and terrain databases (coordinating with IS.63 and IS.70);
  - physics-based models and databases of below-ground features and foreign structures and facilities
  - modeling of interiors of buildings;
  - modeling of chemical/biological sensors and hazard movement in urban ca
  - access to and integration of micro-meteorological data;
  - human models that react appropriately to chemical/biological attacks;
  - verification, validation, and accreditation of all the above.

Related directly to other DTO's

- **Relations to JWSTP DTOs**
  - JWSTP DTOs provide critical engineering level physical parameters from which to generate synthetic representations for weapons effects
  - **JA.24 Target Find, Characterize, and Assess Enabling Technology**
    - Target modeling will provide common target description data to serve as the input for a ``family of systems`` planning tools approach that covers conventional, nuclear, Special Forces, and information operations attack options
  - **JC.34 Target Plan and Attack Technologies**
    - Investments in tunnel defeat technologies will provide the foundation for the engineering-level models used in operational planning tools.
  - **JC.35 Tunnel Defeat Technology Demonstrations**
    - The data collected during operation and testing are essential for the development of realistic signature libraries for the various tunnel operations and for full-scale test and validation of the target planning tool models.
- **Achievements**
  - High fidelity weapons effects model integrated into Volk Field training range. Seven more - FY04-06.
  - Urban Dispersion Model validated, verified and chosen for integration into Joint Effects Model (JEM).
  - Integrated federation chosen by Joint Operational Effects Federation JPO as basis for prototype.
  - Weapons Effects model chosen as core simulation for JFCOM Distributed Continuous Experimentation Environment.

IS.63 Integrated Physical Environment

- **Objective: Provide readily available, authoritative environmental data at the appropriate spatial and temporal resolution for use in simulations**
- **Environmental Scenario Generation develops viable atmospheric representations for DoD M&S users**
  - **It's no longer too hard**
  - **It no longer takes too long**
  - **It's no longer too expensive**
- **Technical Approach**
  - **Exploit basic technology from R&D programs for modeling and predicting environment (global, regional and mesoscale models)**
  - **Determine correct resolution for sensors and systems**
    - **Using real world requirements and performance specifications**
  - **Develop ability to reanalyze real world data to produce right resolution**
    - **Produces ACMES to use catalog data to reproduce dynamic weather**
    - **Has been transitioned to operational AF (Combat Climatology Command)**
  - **Capitalize on METOC knowledge to develop scenarios (time span, resolution, critical environmental features) to support specific needs**
  - **Provide data in known format to simulation users**

To get the right environmental data

- **Impact: AND IT MAKES A DIFFERENCE in simulation outcomes**
  - **Sensor perception is physically correct**
  - **Planning, rehearsal, training, T&E function appropriately**
  - **Tested and proven in JWARS and JSAF (FBE). Recent results in JWARS showed effect of a typhonic weather pattern in Pacific on performance.**

Human Performance

The Problem

- The military is engaged in new missions:
  - Asymmetric warfare against transnational terrorists
  - Stability and Support Operations
- Preparing for these missions requires new classes of models and simulations:
  - Crowd models
  - Non-lethal weapon effects models
  - Simulations to test and evaluate Rules of Engagements (ROE)

The Solution

- Algorithms and other techniques to represent socio-cultural knowledge
- Crowd conceptual models and behavioral moderators
- Framework and software tools for defining ROEs, tactics, behavior models, moderators
- Research testbed to quantify the role of personality and cultural factors in military operations
- Non-lethal weapons employment behaviors for individual entities

Metrics and Benefits

- Tools to evaluate the risks and possible outcomes of specific missions
- Improved analysis, training, and mission rehearsal from behavioral models that incorporate cultural, ethnic, religious beliefs
- Environment to systematically evaluate ROEs for effectiveness, clarity, unforeseen implications, and reliability
- Testbed for the study and experimentation of alternative approaches for NLW employment

Focus Area: Simulation Information Technology

Develop data models, database and data transfer standards to enable rapid scenario development and connection between simulation and operational systems.

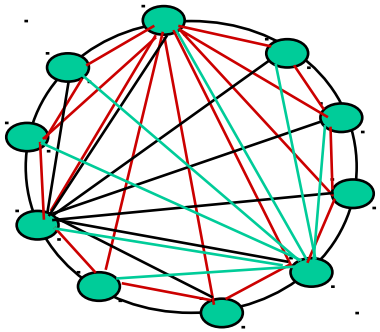
- **IS.70, SEDRIS: Synthetic Environment Data Representation and Interface Specification (closing)**

Prior DTO's produced
Functional Description of the Mission Space
Unit Order of Battle Tool

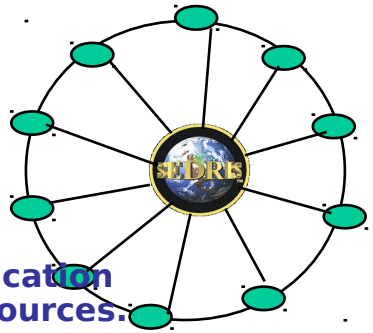
Near Term Goals	Mid Term Goals	Far Term Goals
Support major DoD programs with information exchange standards, identification and access to authoritative modeling and simulation data. **Create robust, comprehensive policy & guidance in support of VV&A of DoD M&S.** **Conduct research projects to address and resolve the technical challenges impacting the implementation of VV&A across DoD.**	**Establish a meta-language description of these capabilities in a commonly used standard representation like XML.** **Publish standards for general use and have them instantiated in DoD data standards.**	**Express military systems and missions in self-describing, error correcting codes that will enable automation of scenario development.** **Transform technical innovations in verification and validation methodologies into automated support for validation and accreditation processes.** **Automate the VV&A process.**

IS.70 SEDRIS

- **OBJECTIVE**
  - **SEDRIS™ technologies provide the means to represent environmental data (terrain, ocean, air and space), and promote the unambiguous, loss-less and non-proprietary interchange of environmental data.**



SEDRIS removes the need to translate among multiple terrain databases by providing a single, module that accepts a SEDRIS API from any format and translates that into an API in the desired format.



MCO2: SEDRIS provided the translation and verification Capability for simulations and saved time and resources.

- **SEDRIS is fundamentally about two key aspects:**
  (1) representation of environmental data (unambiguous definition), and
  (2) the interchange of environmental data sets.
- **To achieve the goal of broad use, the fundamental parts of SEDRIS are in the process of becoming standards under the International Standards Organization**
  - **By October, all major components together with their software bindings will be through the final committee draft of the ISO.**
  - **Final standards approval will be automatic within 6 months when standards will be published**

Users include: Army, Navy, TENA
SEDRIS is part of the Joint Technical Architecture and will be integrated into the GIG

Focus Area: Frameworks for Interoperability

Develop technologies, tools, standards, databases, and repositories that support the interoperability and reuse of M&S resources across heterogeneous systems and applications

IS.69, Operations Other Than War Simulation (closing)

IS.72, Integrated Live, Virtual, and Constructive Joint Urban Operations Training (short term, closing)

IS.78, Modeling Architecture for Technology, Research, and Experimentation (new DTO)

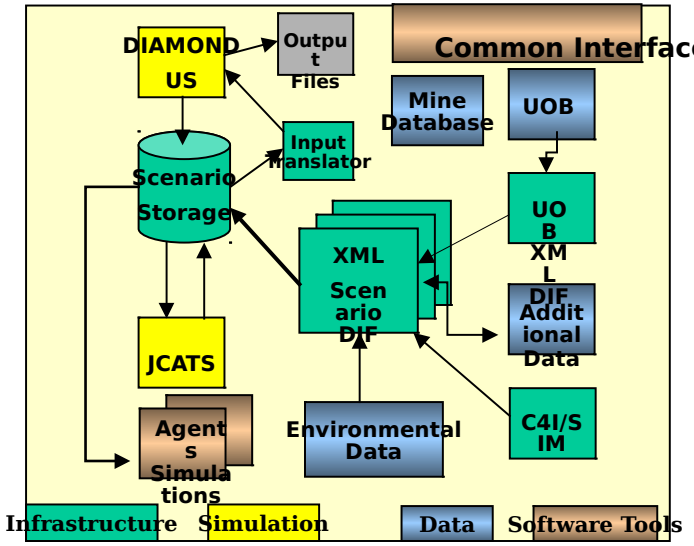
IS.81, Composable Modeling and Simulation Framework (new DTO)

Near Term Goals	Mid Term Goals	Far Term Goals
Identify and develop initial elements of a Composable Mission Space Environment (CMSE) by both utilizing formal specification and experimental environments, and identifying underlying technical challenges. Extend to integrating M&S and C4I systems	With CMSE approaches, develop prototype distributed collaborative environments (CEs), ensuring CE components and M&S components easily integrate with one another and with C4I systems.	Exploit CMSE as a fully capable distributed CE, with an automated capability to select and assemble components (hardware, software, databases, etc.) in various combinations into complete, validated simulation environments to satisfy specific user requirements across a variety of application domains, levels of resolution, and time scales. Includes linkages to range instrumentation and live military systems

IS.69 Operations Other than War Simulations: A Portable, Composable Environment

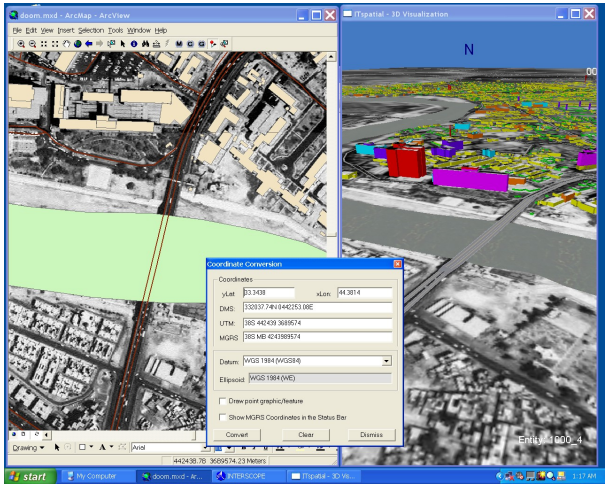
OBJECTIVE

- Develop a technical architecture to leverage M&S developments to support modeling Operations Other Than War
- Provide a framework to enable the use of a multitude of tools and technologies in support of OOTW modeling
- Prove architecture by populating it with existing and emerging M&S tools
- Transition tools to the Warfighter and other M&S programs as appropriate
- Target Windows laptops for operational utility



Accomplishments: Delivering capability to operational units

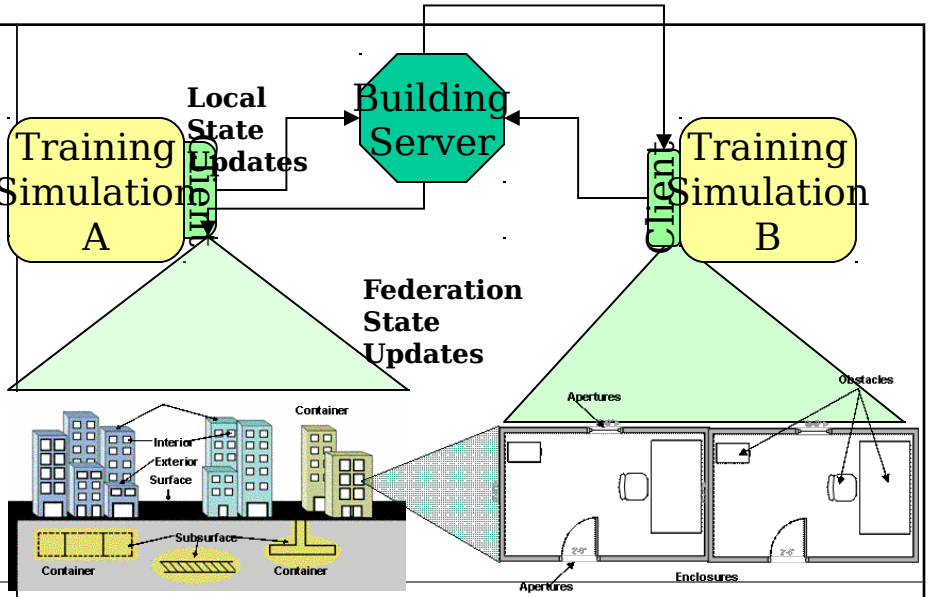
- **FiRST:** Spawned from OOTW Program and Smart Sensor Web, linked live sensor feeds to 3D viewer
  - Delivered to NYC PD post 9/11
- **MCATT:** interactive visualization tool combining the latest 3D viewer technology with a Geographical Information System coupled to JCATS simulation
  - Delivered to USMC prior to Operation Iraqi Freedom
- **FAST:** parent program interfacing dissimilar simulations with common databases and scenario development tools
  - Delivered to CAA, currently deployed in Iraq on pre-Beta Test
  - Incorporates an alpha level tool to rate and predict factors deemed critical to peace-keeping and nation building



JOUST Building Server

The Problem

- LVC operation relies on using diverse simulations, simulators and C4I systems where reworking all databases for every exercise is prohibitively costly
- Requires low-cost solution that enables legacy simulators and simulations to interact with high definition terrain, including urban environments without modifying databases
- Enable consistent interpretation of data, particularly urban



The Solution

- Client-server architecture to provide very large number of buildings (1M+) to include interior details (scalable)
- Building server communicates condition of building among training systems (supports adjudication of building damage state)

Break-through Capability

Metrics and Benefits

- Supports faster, less costly M&S database development by separating base terrain data from highly detailed cultural features data
- Standardized (reusable) components for Joint urban training provide complex cultural features
- Reduced overhead to develop and maintain M&S system for urban training by reducing need to recompile M&S terrain databases
- Provides multi-resolution and composable simulation environments through the use of client-server architecture

MATREX Payoff

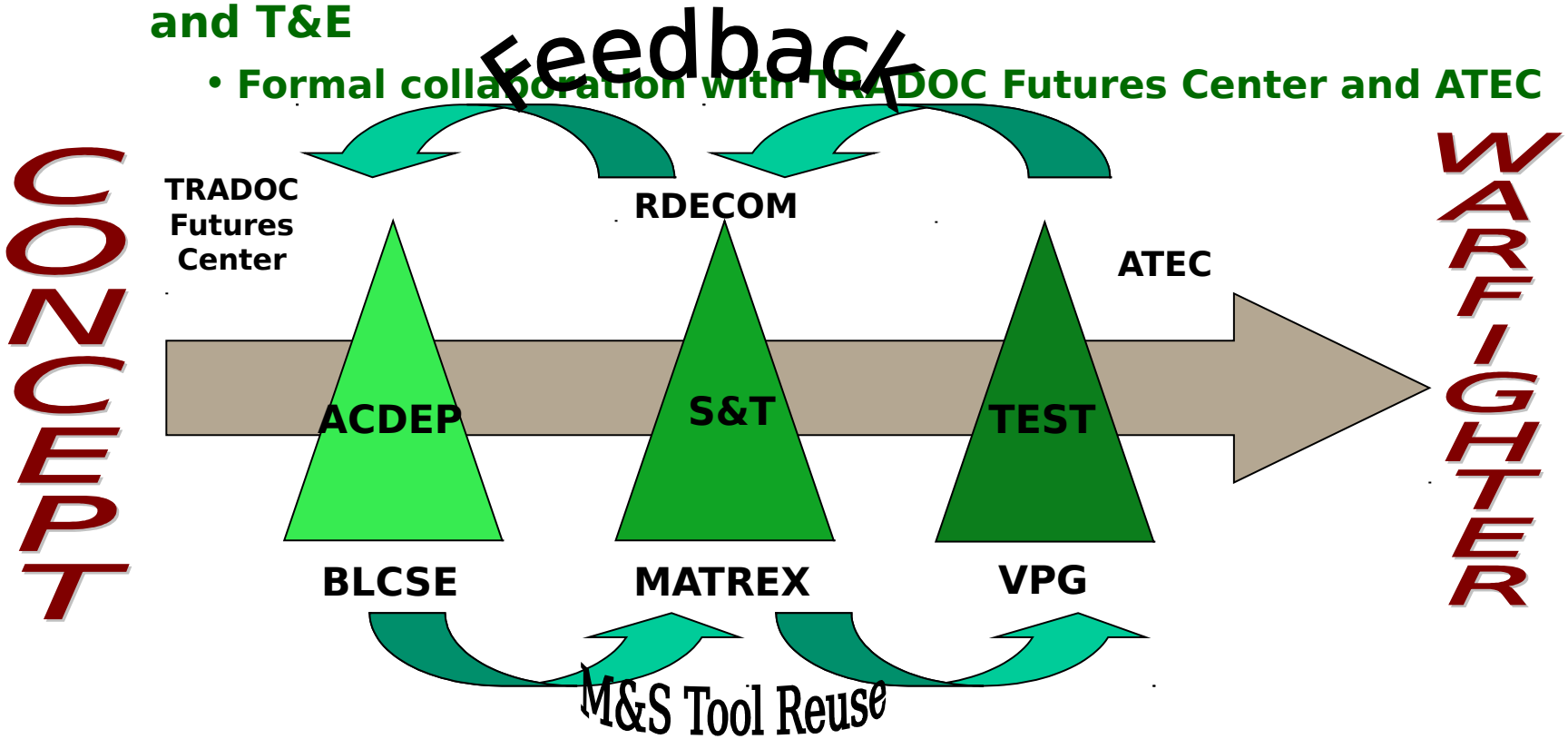
The RDECOM M&S Framework for Systems of Systems RD&E

- **The basis of FCS LSI Simulation Virtual Framework (SVF)**

Critical component to enable "concept to product" for the warfighter

Enables critical collaboration between Requirements, S&T, and T&E

- **Formal collaboration with TRADOC Futures Center and ATEC**



Conclusion

MATREX DTO is coordinated with:

- **FCS LSI and Test & Eval Community**
- **TRADOC Experimentation & M&S activities**
- **JOINT**
  - **Joint Forces Command J9 (Experimentation)**
  - **Joint Synthetic Battlespace (Air Force)**

Will provide a Scalable, variable fidelity, Simulation Environment

Will be a critical element in spiral technology insertion

- **Provide direct support to Mature Technology Spiral Integration Process**
- **Direct transition from simulation "WORKBENCH" to the field**
- **Published interfaces will allow use of non-Army M&S tools**

Will reduce materiel fielding timeframe

Objective: Build a simulation architecture & capability that enables implementation, simulation, experimentation and analysis of Network Centric Warfare

Composable Frameworks

Near-Term

- HLA 1516 Evolution (2005 review)
- BOM
- Composable Model Based Architectures
- Physics-Based Sensor Server: EO Server
- Algorithm Servers: ATLoS

Mid-Term

- Executable Architecture Models
- Extensible M&S Framework: XMSF
- Representations and Metadata

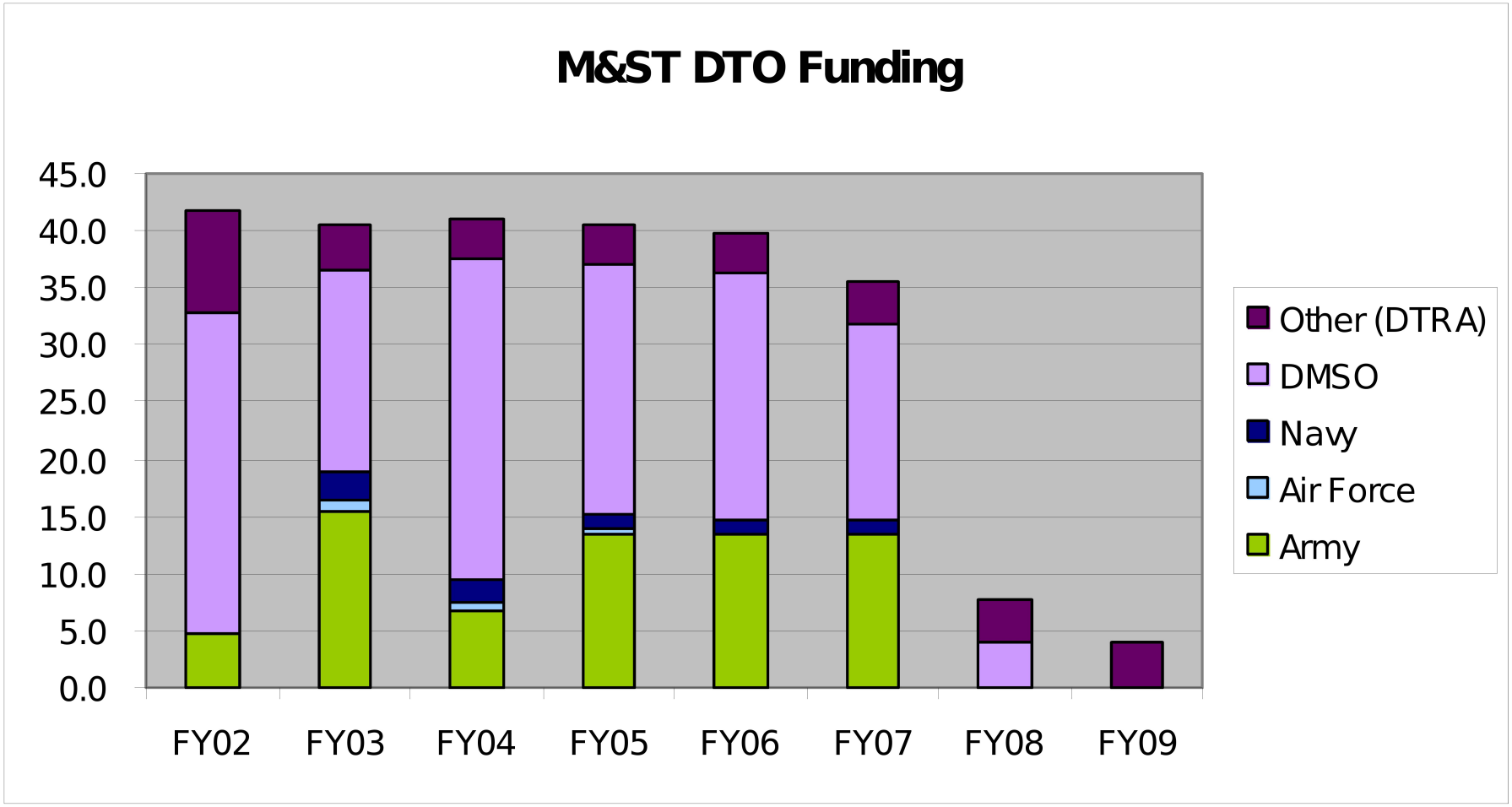
Long-Term

- Semantic Meta-Model (conditions for composition)
- Semantic Descriptions
- Ontology of Physics

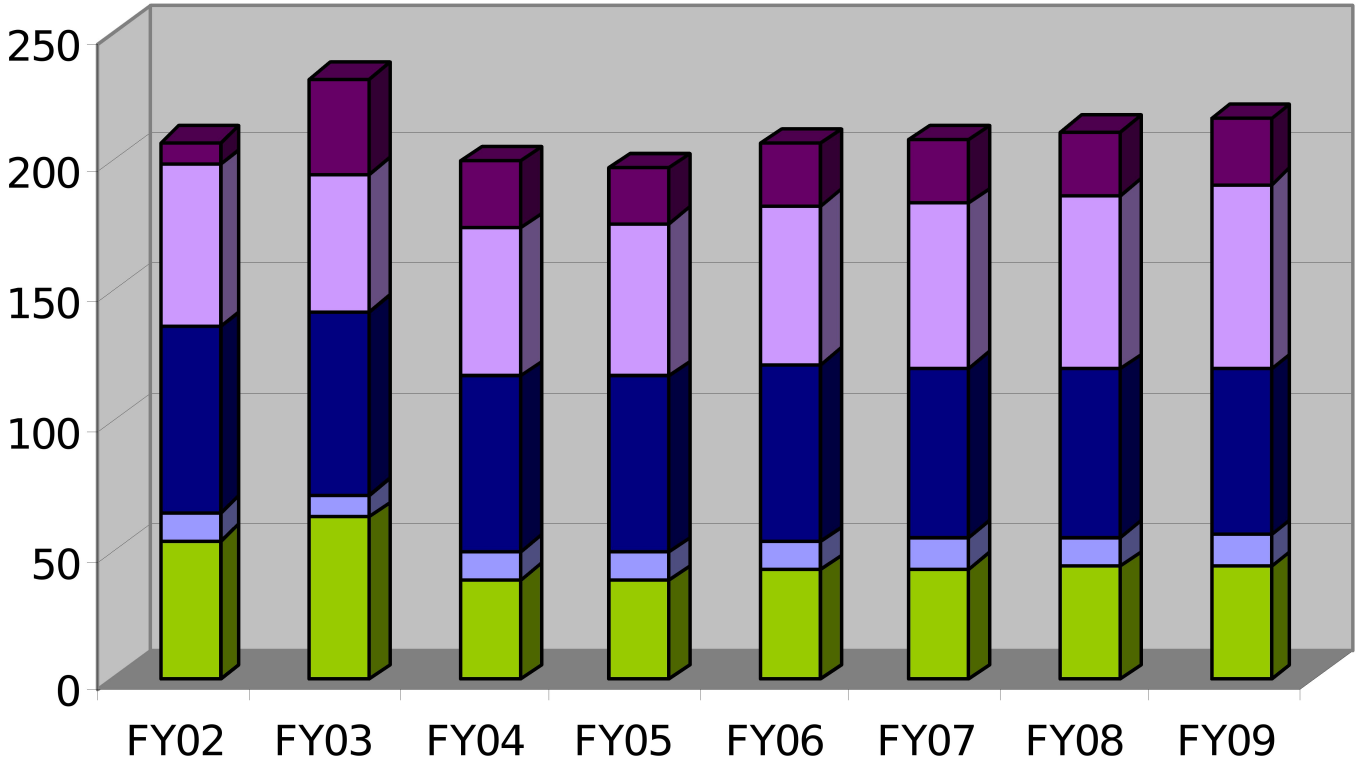
What Are We Trying to Achieve Through Composability?

- The “fair fight”
- Ability to assemble and re-assemble components rapid and flexibly
- Ability to create, use and share data reliably
- Ability to assemble diverse pieces – simulations and operational systems – architectures and simulations
- Understanding “a priori” that an assembled set of components will be fit for use
- Reducing the time and level of expertise needed to build a simulation
- Ability to assemble models of diverse type and share data, scenarios and results easily and reliably

Modeling and Simulation Technology
DTAP DTO Funding



Modeling & Simulation Technology Total Funding



Defense Technology Area Plan for M&S Technology

- Static environments
- Standard architecture
- Well defined APIs
- IEEE 1516 standard
- Natural environment moving to IEEE standards

Current

Near Term 2004-09

- Consistent, interoperable synthetic battlespace
- Rapidly configurable human representations
- Representations of the full spectrum of national defense issues

Mid Term 2009-13

- Dynamic rather than static environments
- Robust consistency between live and simulated assets
- Validation down to algorithmic level

Far Term 2013+

- Rapidly Composable and Scalable Models & Simulations
- Multi-resolution Model and Object Design
- Automated Capture of Reasoning / Context
- Flexible link of Decision Support Systems (DSS) and Simulations

Readily Available, Operationally Valid Models & Simulations

Analysis

Experimentation

Acquisition

Training